Modeling Consumer Choice among Three-Part Tariffs

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We develop a discrete/continuous model of consumer tariff choice and demand for Internet access under three-part tariffs. To explain actual consumer behavior we account for consumers' heterogeneous preferences over usage, tariff-specific preferences and consumers' uncertainty about their future usage at the time of tariff choice.

1. Introduction

In recent years, firms in a number of industries have introduced wide menus of pricing plans that grant access to a virtually identical product under different pricing schemes. These menus of tariffs allow consumers to self-select into the tariff that best fits their demand. They include pure pay-per-use tariffs, tariffs where the consumer pays an access price, and a marginal price only for usage that exceeds a pre-defined usage allowance, as well as flat-rate tariffs. Tariff menus are frequently offered for products and services such as telephone service, Internet access, car rental services, health clubs, or even museums and amusement parks. Among different pricing schemes for such tariff menus, three-part tariffs are becoming increasingly popular for new telecommunication services such as mobile phone service or Internet access, but also for services such as car rental. A three-part tariff is defined by a fixed access price, an included usage allowance at no additional charge, and a marginal price for any usage in excess of the allowance. The inclusion of an allowance is the main distinction between the three-part tariff and the other tariff structures mentioned above.

Proper modeling of consumer tariff choice and usage behavior under three-part tariffs is of relevance to both the provider's pricing and the measurement of consumer welfare in such industries. A detailed knowledge of consumer tariff choice and usage behavior under three-part tariffs improves the provider's ability to match consumers' heterogeneous tastes in pricing, to ultimately reduce customer churn, and to increase profit. Casual evidence suggests that a large number of providers experiment with the various components of their tariffs primarily based on competitive assessments and market intuition, but less based on insights into consumers' tariff choices and usage behavior. For example, one European Internet service provider had more than ten changes in its tariff structure over a period of only six months. Pricing complexity increases further for new services, for which usage behavior changes rapidly over time, as is true for Internet access. As Internet usage has grown, flat-rate tariffs have replaced three-part pricing structures in the US Internet access market almost completely, while they continue to be used in many European countries. Apart from differences in the

competitive environment or in cost, such divergent pricing behavior may also be the result of a suboptimal analysis of demand.

Despite the prevalence of three-part tariffs in practice, the empirical literature on consumer tariff choice and usage behavior under nonlinear prices is sparse (for exceptions see Iyengar, 2005; Lambrecht, Skiera, 2006). Due to the presence of a usage allowance, consumer behavior under three-part tariff pricing is more complicated than under two-part tariff pricing and prior results do not transfer or extend easily to the more complex tariff structure.

The objective of this paper is to develop a model to comprehensively analyze consumer tariff choice and usage for a menu of three-part tariffs. Our model of the consumer's decision process allows for the simultaneous analysis of consumer tariff choice and usage to capture the interdependencies between the two decisions. We extend existing models to the case of three-part tariffs under consumer uncertainty over usage. We assume that the consumer makes her tariff choice based on expected usage to capture the fact that the plan choice occurs prior to the usage decision. We investigate the role of demand uncertainty in the tariff choice and allow for tariff-specific preferences to drive tariff choice independent of usage considerations.

We begin with a review of the literature on consumer demand in the context of a mixed discrete and continuous choice situation. We then present our data to motivate the specification of our model. Next, we develop a model of consumer tariff choice and usage under three-part pricing and conclude with a discussion of the use of such a model to analyze profit and welfare implications of three-part tariff pricing.

2. RELATED LITERATURE ON CONSUMER DEMAND OF SUBSCRIPTION SERVICES

Consumer demand under three-part tariff pricing is challenging to analyze empirically since each component of the menu of tariffs influences household usage and churn behavior, including the access price, the marginal usage price, the amount of the usage allowance, and the number of tariffs. As a result, demand under three-part tariffs has to date not been analyzed extensively in the literature. Most analyses of subscription services focus on demand under two-part tariffs consisting of an access and a usage price in a monopoly setting. This includes work by Danaher (2002), Essegaier *et al.* (2002), Miravete (2002a), Miravete (2002b), Narayanan *et al.* (2005), Train *et al.* (1987), Kridel *et al.* (1993), Kling and van der Ploeg (1990).

The only work on demand under three-part tariff pricing in a competitive environment is Iyengar (2005). He analyzes the effect of access and marginal prices on usage and customer lifetime value for wireless phone usage. He incorporates customer churn by giving consumers an option to disconnect their service but does not model the option to churn in detail. The analysis of changes in usage allowance and the number of tariffs is another important topic. Narayanan *et al.* (2005) provide a first analysis in the context of two-part tariffs and a comparison of one versus two optional tariffs.

The model we use builds upon Hanemann (1984) who analyzes the usage decision as a continuous choice and links the discrete and continuous choices in the same utility maximization problem (see Dubin, McFadden, 1984; Hausman *et al.,* 1993 for applications in telecommunications and

electricity). Extensions of this work include Iyengar (2005) and Economides *et al.* (2005) who incorporate nonlinear prices in wireless and wireline telecommunications into a discrete/continuous model. They assume that the household can perfectly predict its usage at the time of the calling plan choice. However, they may have difficulty in correctly predicting the household's tariff choice, as they do not recognize systematic error caused by demand uncertainty. This is particularly important when usage is variable and hard to predict at the time of the tariff choice. It is this assumption that we relax in this paper.

The model presented below most closely resembles the one used by Narayanan et al. (2005). In contrast to their work, we focus on demand in the context of three-part tariffs. The model provides one justification for a systematic preference by households for a flat-rate tariff beyond pure usage considerations termed a «flat-rate bias» by several authors (Train et al. (1987), Nunes (2000), Lambrecht (2005), Lambrecht and Skiera (2006)). In contrast to previous models that focus on demand under monopoly we also incorporate the possibility of customer churn.

Thus, in the literature on demand modeling we are the first to build a discrete/continuous model for the choice between optional three-part tariffs allowing for demand uncertainty and explicitly modeling the option of customer churn.

3. Data

We motivate our model using data from a German Internet Service Provider for a representative sample of 10,882 customers with DSL Internet access. Each customer has a choice of one of three tariffs.

(i) Tariff *1* has a fixed fee and a monthly allowance. For usage exceeding the allowance, a marginal usage price is charged per megabyte (MB) transferred.
(ii) Tariff *2* has a higher fixed fee and a higher allowance than tariff *1*, but the same marginal usage price for usage exceeding the allowance.
(iii) Tariff *3* is a flat rate with unlimited usage.

We first analyze trends in people's usage relative to their allowance. On average over three months, 11.7% of customers on tariff *1* and 12.7% of customers on tariff *2* exceed their allowance in transmission activity. Due to the stepwise tariff structure, even these households may still be on the cost-minimizing tariff, however. Examining the extent to which consumers choose the tariff that leads to the lowest bill size, based on their ex-post usage behavior, points to two different instances of non-bill minimizing tariff choice. Some consumers who remain within their usage allowance by the end of the month would pay less on a tariff with a lower fixed fee and lower allowance, a situation that the literature has coined a flat-rate bias. In contrast, some consumers who exceed their usage allowance could have paid less by upgrading to a tariff with a higher fixed fee and allowance (a pay-per-use bias).

Figure 1 shows the extent to which consumers have chosen the bill-minimizing tariff (see also Lambrecht, Skiera, 2006). The vertical axis lists the chosen tariff, while the horizontal axis lists the best tariff in terms of lowest bill. The diagonal represents customers who have chosen a tariff that minimizes their bill. Consumers in the lower left-hand corner have a flat-rate bias

and consumers in the upper right-hand corner have a pay-per-use bias. The results show that a significant fraction of customers has a flat-rate bias. There are several possible explanations. Among others, households may prefer a tariff that leads to fewer month-to-month fluctuations in their bill. Also, the tariff choice is based on the household's expected usage at the beginning of the billing period, whereas in the data we observe the household's ex-post usage. The model laid out in Section 0 incorporates both of these possible explanations.

4. MODEL DEVELOPMENT AND ESTIMATION

Model set-up

Each month, consumers make two decisions with regard to their Internet access tariff. First, they choose their tariff. The tariff choice is a discrete choice among the available tariffs and is based on the expected usage for that period. Conditional on the tariff choice, consumers make a continuous usage decision on the quantity they consume that month. The model for consumer demand under the chosen tariff thus needs to incorporate both decisions and the mutual interdependence of tariff choice and (expected) consumption. This is the case in a discrete continuous choice model.

Utility Function. The consumer has a choice between a set of J three-part tariffs. Each tariff j is defined by a monthly access fee, denoted by F_j, a usage allowance measured in megabyte (MB) of data transmission included in the tariff at no additional charge, $\tilde{q}_j$, and a marginal price p_j charged for each MB of usage that exceeds the tariff's monthly allowance. Across tariffs, a higher fixed fee is associated with a higher allowance, so that $F_j < F_{j+1}$ and $\tilde{q}_j < \tilde{q}_{j+1}$. For simplicity, we limit J to three tariffs and consider a choice between two three-part tariffs, denoted by tariffs *1* and *2* and one flat-rate tariff, with an unlimited usage allowance or $\tilde{q}=\infty$ so that $<F_1<F_2<F_3$ and $\tilde{q}_1<\tilde{q}_2<\tilde{q}_3=\infty$. We assume that the marginal price for usage exceeding the allowance is identical for tariffs *1* and *2* and is denoted by p. In our model, consumer i making a choice of tariff j at time t maximizes the following utility function:

$$U_{ijt}(q_{ijt}, q_{Ojt}) = \frac{c_i}{b}\left(d_{it}q_{ijt} - \frac{q_{it}^2}{2}\right) + c_i q_{Oit} - \frac{d_{it}^2}{2b} + \varsigma_{ijt} \quad (1)$$

where q_{ijt} is the usage volume on tariff j, q_{Oit} is the consumption of the outside good and ζ_{ijt} the vector of observable and unob-

FIGURE 1.
TARIFF-CHOICE BIASES

		Best Tariff		
		Tariff 1	Tariff 2	Flat Rate
Chosen Tariff	Tariff 1	93.7%	5.3%	1.0%
	Tariff 2	48.1%	43.4%	8.5%
	Flat Rate	19.8%	8.4%	71.8%

servable consumer and plan-specific characteristics. The household chooses consumption levels for q_{ijt} and q_{Oit} that maximize its utility subject to his budget constraint. This allows us to derive the conditional indirect utility function, where y_{it} denotes the consumer's income:

$$V_{ijt}(y_{it}, p_j, F_j) = c_i\left[\begin{array}{l} y_{it} - F_j + p_j\tilde{q}_j \\ -\left(d_{it} - \frac{1}{2}bp_j\right)p_j \end{array}\right] + \varsigma_{ijt} \quad (2)$$

and the consumer's demand for usage,

$$q_{ijt} = d_{it} - bp_j \quad (3)$$

Tariff Choice. A consumer's tariff choice is driven in part by plan-specific preferences, ζ_{ijt}, which are known to the consumer at the time of her tariff choice, but unobserved by the researcher. Such preferences may reflect a household's inherent preference for a flat-rate tariff. We capture the fact that the household's tariff choice takes place separately from, and before, its usage decision by allowing for household uncertainty over its ultimate usage. We incorporate a usage shock, V_{it}, into the household's demand to reflect random variation in usage. We specify V_{it} to be a normally distributed usage shock that shifts demand, but leaves the demand's slope unaffected, so that $d_{it} = \exp(a_{it}+v_{it})$.

Following, we model the household's tariff choice conditional on the expected utility in the alternative tariffs. We find that the choice of tariffs *1*, *2*, or *3* is governed by the variance of the household's usage shock σ_v^2 and the relative costs of the tariffs. For example, in choosing among the two three-part tariffs, a household prefers tariff *1* to tariff *2* if the expected conditional indirect utility of tariff *1* exceeds the one of tariff *2* or $E[V_{i1t}] \geq E[V_{i2t}]$. This entails that the household chooses tariff *1* if:

$$\begin{aligned} &\frac{\varsigma_{i1t} - \varsigma_{i2t}}{c_i} - (F_1 - F_2) \\ &\geq p_j\left(a_{it} - \frac{1}{2}bp_j - \tilde{q}_1\right)(1 - \Phi(x_{i1t}(\sigma_v))) \\ &-p_j\left(a_{it} - \frac{1}{2}bp_j - \tilde{q}_2\right)(1 - \Phi(x_{i2t}(\sigma_v))) \\ &+\sigma_v p_j\left\{\phi(x_{i1t}(\sigma_v)) - \phi(x_{i2t}(\sigma_v))\right\} \end{aligned} \quad (4)$$

where Φ and ϕ denote the normal probability distribution and density functions. x_{ijt} denotes the normalized cutoff for V_{it} such that consumption exceeds the allowance for values greater than x_{ijt}. For more detail on the model derivation, see Lambrecht *et al.* (2005). Intuitively, the household trades off the certain components of its indirect utility from fixed fees and its tariff-specific preferences to the uncertain components that depend on the variance and the realization of the usage shock. The left-hand side of equation (4) represents the tariffs' fixed fees and its individual preferences for either tariff, whereas the right-hand side includes the difference in expected indirect utility if the household's usage exceeds either of the tariffs' allowance and a disutility induced by the variance in the household's expected usage. The higher the variance in expected usage the more likely is it that the household prefers tariffs with a high or unlimited allowance of data transmission to tariffs with a low allowance. This is apparent in comparing the expected utilities of one of the two three-part tariffs to the one of the flat-rate tariff. A household prefers tariffs *1* or *2* to the flat-rate tariff *3* provided:

$$\frac{\varsigma_{ijt} - \varsigma_{i3t}}{c_i} - (F_j - F_3) \geq -p_j$$

$$\left(\mu_{\exp(v)\left|\exp(v)>\exp(\sigma_v x_{ijt})\right.} e^{a_{it}} - \frac{1}{2} bp_j - \tilde{q}_j\right) \quad (5)$$

$$(1 - \Phi(x_{ijt}(\sigma_v)))$$

that is if the certain benefits entailed by the three-part tariff in the form of tariff-specific preference gains net of the fixed-cost difference between the tariffs exceed the disutility induced by the uncertain usage. The uncertain usage induces disutility for tariffs *1* and *2* due to a possibility of exceeding the allowance in the form of additional usage charges and variation in usage.

Model estimation

The model laid out above can be estimated via maximum likelihood. The likelihood of seeing a particular household's tariff and usage choice is given by the likelihood of observing the household's usage conditional on its tariff choice times the likelihood of its tariff choice. The model's parameters are in general identified by observing systematic variation in household characteristics and prices that translate into variation in choice and usage behavior. Given the tariff structure, we only observe two levels for the marginal price, a price of zero on the flat-rate tariff and for usage in tariffs *1* and *2* that is below allowance $\tilde{q}_j$, and a positive price for tariffs *1* and *2*. The price coefficient is then identified by observing the same household's usage choices under these two price levels, that is observing household usage if the household exceeds its allowance and pays a positive marginal price and usage if the household remains within its allowance or consumes on a flat-rate plan with a zero marginal price.

5. Implications for pricing Internet access

The parameter estimates that result from the estimation of the model of consumer tariff choice and usage could be used to assess access and usage price elasticities and analyze the role of provider pricing in consumer choice behavior. Counterfactuals that may be of interest to a provider include an assessment of the impact of changes in the components of a tariff on the company's profit and on consumer welfare. Second, the parameter estimates could be used to investigate the effect on profitability of systematic changes in demand due to increased Internet usage. The provider could use such results to forecast the predicted consumer behavior under alternative tariff structures to develop its optimal response to systematic usage changes.

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